

RESTORING CONSTRUCTION METHOD FOR UNEVENLY SETTLED BUILDING

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Riassunto

PURPOSE: To provide an economical restoring construction method in which even an unevenly settled building of great weight and having wide foundation (multistoried building) can be restored safely and easily in a short period of time, using a soil improvement technic by means of chemical infection.

CONSTITUTION: A plurality of chemical liquid injection rods 5 are set at required intervals so that an end of each of the rods is positioned in the lower part of a foundation 2 of a building to be constructed. A quick setting chemical liquid in required quantities is successively switched and forced into chemical injection points at required time intervals by means of the rods 5, and the chemical liquid is repeatedly forced into a strengthened soil layer 31 at each chemical injection point, into which chemical liquid has been injected, and into cracks of homo-gel of a chemical liquid, whereby reaction forces are gradually increased by the layer 31 so that the building together with the foundation can be raised to a normal state.

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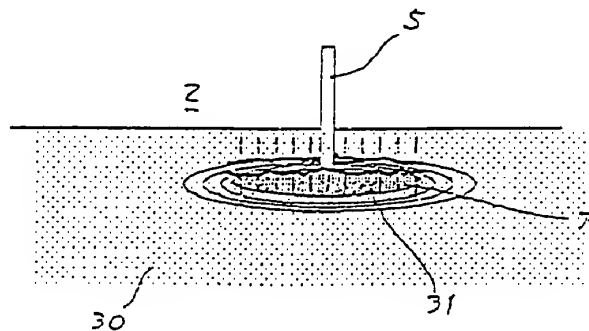
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(51) 【発明の名称】 不等沈下構造物の復元工法

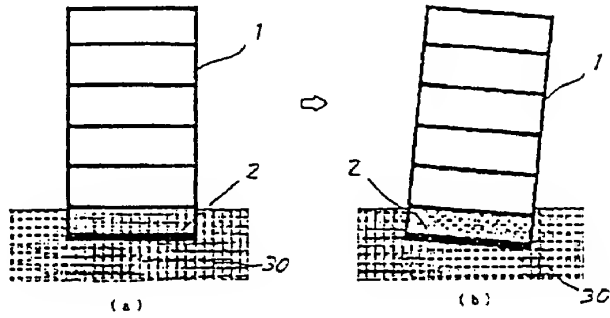
(57) 【要約】

【目的】 基礎部が広くて大重量の構造物（多層階の建築物）であっても、薬液注入による地盤の改良技術を用いて、安全にかつ無理なく、短期間で復元することができる経済性の高い不等沈下構造物の復元工法を提供する。

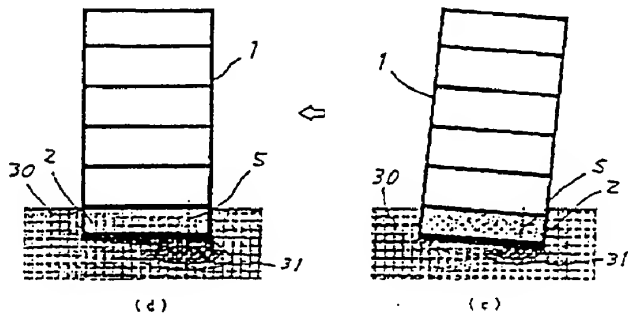
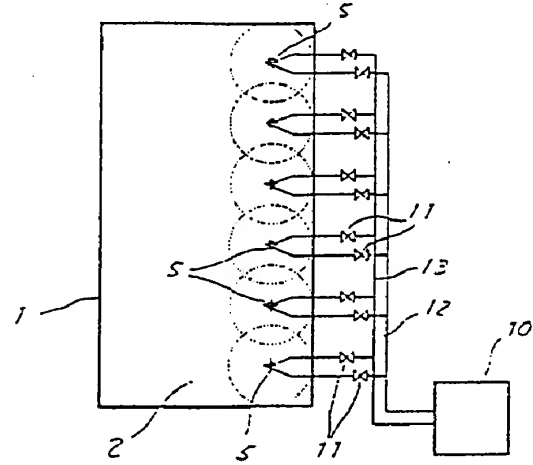
【構成】 目的構造物の基礎2下部に先端吐出部が位置するように所要の間隔で複数の薬液注入ロッド5を設置し、これら薬液注入ロッド5によって瞬結性の薬液を所要のインターバルで各薬液注入箇所へ順次切替て圧入し、各薬液注入箇所において先に注入され強化された地盤強化層31及び薬液のホモゲル部に割裂状態で繰り返し前記薬液を圧入することにより、その地盤強化層31分で反力を次第に増大させる薬液注入操作によって基礎部とともに構造物を持上げ正常状態に復元させる。



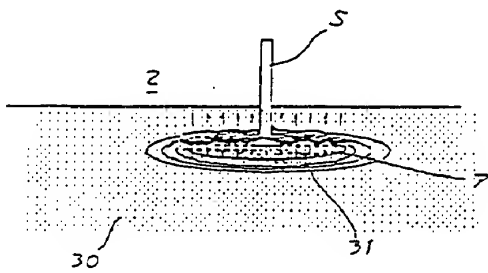
【図1】



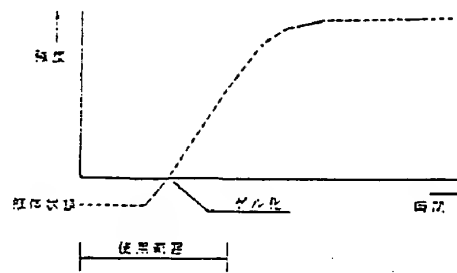
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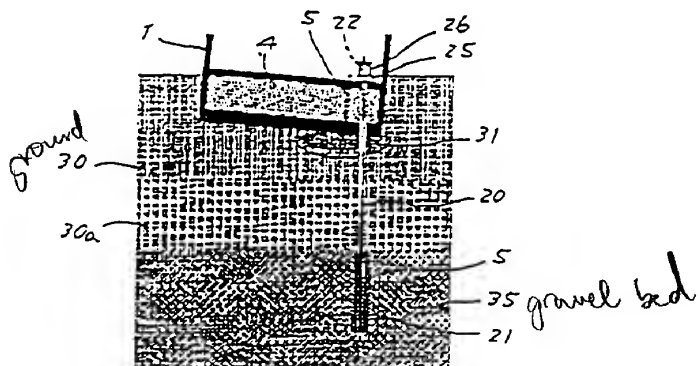
【図3】



【図4】



【図5】



Ref. foundation creates a plate to the foundation or a lower area

JP 8-260500 (translation)

[Title of the Invention] RESTORING METHOD FOR UNEVENLY SETTLED BUILDING

[Abstract]

[Object]

To provide a highly economical restoring method for an unevenly settled building in which even an unevenly settled building of great weight and having wide foundation (multi-storied building) can be restored safely and easily in a short period of time, using a soil improvement technique by means of chemical liquid injection.

[Constitution]

A plurality of chemical liquid injection rods 5 are set at predetermined intervals so that a discharging end of each of the rods is located at the bottom of a foundation 2 of a building to be restored. A flash setting chemical liquid is injected successively at predetermined intervals while changing chemical liquid injection points by means of the rods 5, and the chemical liquid is repeatedly injected by cracking into a reinforced ground layer 31 at each chemical injection point, into which the chemical liquid has been injected, and homo-gel of the chemical liquid, whereby reaction forces are gradually increased by the layer 31 so that the building together with the foundation can be raised to a normal state.

[What is claimed is:]

[Claim 1]

A restoring method for an unevenly settled building

723 - the process is executed in a non-workout condition

characterized by setting a plurality of chemical liquid injection rods at predetermined intervals so that a discharging end of each of the rods is located at the bottom of a foundation of an object structure, injecting a flash setting chemical liquid successively through the chemical liquid injection rods into chemical liquid injection points at predetermined intervals while changing the injection points, repeating the injection of the chemical liquid by cracking into a ground layer reinforced with the previously injected chemical liquid and a homo-gel of the injected chemical liquid at each of chemical liquid injection points so that a reaction force is gradually increased at the injection points, thereby to lift up the structure together with the foundation to be restored to the normal condition.

[Claim 2]

The method according to claim 1, characterized in that the intervals of successively injecting the flash setting chemical liquid into the chemical liquid injection points at predetermined intervals while changing the injection points are taken as an intermediate point of a strength-expression time in a strength-time curve of the injected chemical liquid.

[Claim 3]

A restoring method for an unevenly settled building characterized by inserting a required number of anchors of a required length into a ground below a foundation of an object structure to a required depth and fixed, or placing a loading material on the foundation, and setting a plurality of chemical liquid injection rods at

predetermined intervals so that a discharging end of each of the rods is located at the bottom of the foundation of the structure, injecting a flash setting chemical liquid successively through the chemical liquid injection rods at predetermined intervals while changing chemical liquid injection points, repeating the injection of the chemical liquid by cracking into a ground layer reinforced with the previously injected chemical liquid and a homo-gel of the injected chemical liquid at each of the chemical liquid injection points so that a reaction force is gradually increased at the injection points, and increasing the load than that in a normal condition of the structure by applying a tensile force to the anchors or by the load of said loading material, thereby to promote compaction and reinforcement of a ground layer lying below and to lift up the structure together with the foundation to be restored to the normal condition.

[Claim 4]

A method according to claim 3, characterized in that a required water tank is used as the loading material to be placed on the foundation of the structure and the load is adjusted by increasing or reducing a quantity of water in the water tank.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention primarily relates to a restoring method for an unevenly settled building. More specifically, it relates to a restoring method for an unevenly settled building wherein a chemical

liquid is injected into the ground bearing the unevenly settled foundation and a tilted building body so as to reinforce and improve the ground, and the building body is lifted up with a press-up pressure of the injected chemical liquid to recover and maintain a normal state.

[0002]

[Prior Art]

In general, structures constructed on a stratum such as alluvium will lose the stability of its foundation if a liquefaction phenomenon of the stratum occurs upon a violent impact due to a big earthquake, etc. and a body above the foundation tilts, which makes difficult to maintain the living environment. This has been frequently observed in recent earthquakes.

[0003]

Such a structure with the body tilted generally maintains the body strength on the basis of a general building design, but loses a support force and balance of the body, and thus is tilted because the ground bearing the foundation is flown away due to the liquefaction. Consequently, it is not easy to restore the tilted structure (building).

[0004]

[Problems to be solved by the Invention]

A means generally considered is to lay strong beam members under the lowered side of the tilted structure (building), insert jacks into the clearance between the strong beam members and necessary portions of the foundation, and gradually raise the body with the jacks. However, such a means involves extremely dangerous operations

because the ground must be excavated in order to arrange the strong beam members under the necessary portions of the foundation. Further, preparation works also involve many difficulties, for example, strong jacks are required. In addition, a localized lift-up force is inevitably exerted since the jacks are used, and a great deal of labor and construction period are required if a large area must be supported smoothly to restore the building. Also, workability is not good. Naturally, the means requires much construction costs, resulting in a problem in economy.

[0005]

Accordingly, it is an object of the present invention to provide a highly economical restoring method for an unevenly settled building that will solve this kind of problem, and can restore the unevenly settled building safely and easily in a short period of time, by use of a ground improvement technique of chemical liquid injection even in the case of a large-weight structure with a wide foundation (multi-storied building).

[0006]

[Means for Solving the Problems]

A first restoring method for an unevenly settled building according to the present invention for achieving this object is characterized by setting a plurality of chemical liquid injection rods at predetermined intervals so that a discharging end of each of the rods is located at the bottom of a foundation of a building to be restored, injecting a flash setting chemical liquid successively through the

chemical liquid injection rods at predetermined intervals into chemical liquid injection points while changing the injection points, repeating the injection of the chemical liquid by cracking into a ground layer reinforced with the previously injected chemical liquid and a homo-gel of the injected chemical liquid at each of the chemical injection points so that a reaction force is gradually increased at the injection points, thereby to lift up the structure together with the foundation to be restored to the normal condition.

[0007]

It is desirable that the intervals for successively injecting the flash setting chemical liquid into the chemical liquid injection points are taken as an intermediate point of strength-expression time in the strength-time curve of the injected chemical liquid.

[0008]

A second restoring method for an unevenly settled building is characterized by inserting a required number of anchors of a required length into a ground below a foundation of an object structure to a required depth and fixed, or placing a loading material on the foundation, and setting a plurality of chemical liquid injection rods at predetermined intervals so that a discharging end of each of the rods is located at the bottom of the foundation of the structure, injecting a flash setting chemical liquid successively through the chemical liquid injection rods at predetermined intervals while changing chemical liquid injection points, repeating the injection of the chemical liquid by cracking into a ground layer reinforced with the previously injected

chemical liquid and a homo-gel of the injected chemical liquid at each of the chemical liquid injection points so that a reaction force is gradually increased at the injection points, and increasing the load than that in a normal condition of the structure by applying a tensile force to the anchors or by the load of the said loading material, thereby to promote compaction and reinforcement of a ground layer lying below and to lift up the structure together with the foundation to be restored to the normal condition.

[0009]

In addition, in order to promote the compaction and reinforcement of the stratum below the structure foundation, it is preferable to use a required water tank as the loading material placed on the foundation of the structure and to adjust the loading by increasing or reducing a quantity of water in the water tank. Further, it is preferable that the anchors are planted from the upper part of the structure foundation into the ground below the foundation by drilling to a required depth, a distal end of each of the anchors is hardened and fixed by the chemical liquid, and a load more than the dead weight of the structure is applied by jacks on the upper section of the foundation. By the way, it is desirable to provide these anchors at plural points at required intervals at the foundation of the object structure so as to apply the push-up pressure equally to depths of the ground below the foundation.

[0010]

[Action]

According to the first restoring method for the unevenly settled building of the present invention, the flash setting chemical liquid is repeatedly injected at predetermined intervals into the injection points under the foundation successively in turns from the chemical liquid injection rods provided at predetermined intervals on the bottom of the foundation of the unevenly settled and tilted building, in particular, on the bottom of the lowered side of the foundation. Accordingly, the ground reinforced by the previously injected liquid and the homo-gelled chemical liquid are cracked, a reaction force of the chemical liquid gradually increases and then the building and the foundation are lifted up. Consequently, the building can be restored smoothly and easily in a short time to the normal condition by matching the chemical liquid injection pressure, injection amount, arrangement of the injection points and the like to the rigidity of the foundation of the object building, rigidity of underground beams and push-up load of the building.

[0011]

In this way, by adopting the successive injection of the chemical liquid at predetermined intervals into the plural injection points in turns, the reaction force increasing capacity at each of the injection points can evenly be improved. Consequently, even if the tilt, the height and the construction area of the building may differ, it is possible to optionally meet each situation by adjusting the number of the chemical liquid injection points, chemical liquid injection pressure, injection amount, etc. in accordance with the situations, and the

restoration work can be conducted in a short period of time by preparing the chemical liquid and injecting the chemical liquid.

[0012]

In the method according to the present invention, the intervals for changing the injection points in the multi-point (plural places) injection operation of the chemical liquid is taken as an intermediate point of a strength expressing time in the strength-time curve of the injected chemical liquid. Thus, it is able to give a time for partially cracking the ground reinforced by the chemical liquid injected in advance by the pressure of the following injection of the chemical liquid, so that the repetitive injection of the flash setting chemical liquid can be performed and the intended object can be easily achieved.

[0013]

According to the second restoring method for the unevenly settled building of the present invention, an anchor is inserted from an upper section of the foundation of the tilted building into the solid ground below the foundation to be fixed thereto and a tensile force is applied to the anchor by thrust generated by equipments such as jacks, etc., or a load material (heavy material) is placed on the upper section of the foundation to apply a load greater than the dead weight of the building, and then the same operation as the first method is carried out and the load (the tensile force applied to the anchor or the weight of the loading material) is gradually reduced while keeping balance with the lift-up condition of the foundation. Thus, for example, when the construction ground is a compressive stratum such as a viscous soil

layer of silt, a fast compaction reinforcement of the stratum below the ground reinforced by the above-mentioned chemical liquid injection operation is promoted. As a result, even on the ground such as the compressive viscous soil layer, effects of preventing the phenomenon of tilting the structure again by re-settlement can be obtained.

[0014]

[Example]

Referring to the drawings, an embodiment of the restoring method for the unevenly settled building according to the present invention will be described in detail.

[0015]

FIG. 1 schematically shows a condition in which a tilted building is restored by the restoring method for the unevenly settled building according to the present invention, where (a) shows a case in which the building is in the normal condition, (b) shows a case in which the ground unevenly settles and the building is tilted, (c) shows a case in which the method of the present invention begins to be executed, and (d) shows a case in which the building is restored to the normal condition by the chemical liquid injection according to the method of the present invention. FIG. 2 is a plan view showing a plurality of chemical liquid injection points at the lower section of the foundation of the building shown in FIG. 1 and showing the piping conditions for injecting the chemical liquid. FIG. 3 is a schematic cross-sectional view of an important section showing the conditions of the chemical liquid injection. FIG. 4 is a graph that illustrates a time allowing the

chemical liquid injection in a strength-time curve of the injected chemical liquid.

[0016]

In the method according to the present invention, the conditions of the tilted building 1 (see FIG. 1 (b)) are investigated and grasped, and the optimum operation means is examined. At this time, the subsequent operating conditions are established based on the conditions of a ground 30 that supports a tilted building 1 and a foundation 2.

[0017]

First of all, description will be made on the means for restoring the building 1 shown in the drawings, assuming that the ground 30 is a non-compressive soil layer, for example, a stratum such as a sandy layer, and the foundation 2 is a so-called "raft foundation."

[0018]

It is most preferable to carry out the chemical liquid injecting operation from the inside of the building 1. In such event, taking the relationship among the foundation area, the estimated weight of the structure (the building 1 and the foundation 2), rigidity of the raft foundation, and rigidity of the underground beam, etc. into account, the number of chemical liquid injection rods 5 and the arrangement intervals are established. Consequently, when the foundation area is large, the rigidity of the foundation section is sufficiently large and the estimated weight of the structure is great, a larger number of chemical liquid injection rods are used so as to prevent excessive burden from

being applied to one rod. Conversely, if the foundation area is small and the estimated weight of the structure is small, a smaller number of chemical liquid injection rods 5 are arranged. In addition, if the rigidity of the foundation is small, the number of the chemical liquid injection rods 5 increases to allow the injection of chemical liquid to take place more slowly than the former cases. As described above, the operating conditions for the injection are varied to meet the situations of the structure to be restored.

[0019]

For the chemical liquid injection rod 5, a known rod of double pipe structure equipped with a injecting section for injecting a mixture of liquid A and liquid B is used. A plurality of chemical liquid injection rods 5 are inserted into the ground 30 below the foundation by allowing the rods to penetrate through the foundation 2 of the building 1 at required intervals (in general, about 2 meters) as illustrated in FIG. 2. In such event, it is desirable to insert distal end sections of the chemical liquid injection rods 5 to reach the bottom of the foundation so that the rods are arranged in such a manner that a weight lifting reaction force generated against the injection (force-injection) of the subsequent chemical liquid is immediately exerted to the bottom surface of the foundation 2. In addition, it is desirable to sample the stratum in the vicinity of the structure to estimate the conditions of the ground 30 beforehand.

[0020]

After the chemical liquid injection rods 5 are arranged at plural

points at required intervals, supply pipes 12, 13 (hoses, etc.) for the liquid A and the liquid B, respectively, are piped from a high-pressure pump of a chemical liquid supply unit 10 via a selector valve 11.

[0021]

For the chemical liquid to be injected in this context, for example, used is a flash setting grout of about 3 second gelation time in which 100 L of the liquid A containing 50 L soda silicate and 50 L water and 100 L of the liquid B containing 60 kg cement, 20 kg gypsum, and water of the remaining amount are mixed. This is mixed and injected at the ratio of 1 to 1. The composition of the chemical liquid is not restricted to the one mentioned above, but any composition suited for varying the gelation time can be used.

[0022]

In addition, this kind of chemical liquid is supplied at a discharge rate of about 10 to 20 L/min and a pressure of about 30 to 100 kg/cm² by the high-pressure pump of the chemical liquid supply unit 10.

When the estimated weight of the object structure is small and the ground is of a sandy layer, in which the injection speed is comparatively fast, the injection can be performed at low pressure. In this case, it is possible to inject the liquid in a greater amount taking the environment around the structure into account, and if the liquid can be injected at a greater injection rate, the restoration operation can be carried out in a shorter construction time. Conversely to these conditions, if the estimated weight of the structure is large, the injection pressure must be increased and the injection rate may be reduced in inverse

proportion to the injection pressure. In any cases, these parameters will be chosen in conformity with the conditions of the object structure, and the optimum parameters will be established during the restoration operation.

[0023]

As to the injection of the chemical liquid, first of all, the chemical liquid injection rods 5 are inserted and installed to the required depths in holes excavated in advance from the top surface of the foundation 2 down to the cobble stone layer of the ground 30.

After the chemical liquid injection rods are installed, the flash setting chemical liquids (liquid A and liquid B) are supplied to the chemical liquid injection rods 5 through the supply pipes 12, 13 connected in advance, and the two liquids are mixed at a mixing section at each end of the chemical liquid injection rods 5 to be injected to the ground.

[0024]

The chemical liquid injection rods 5 are arranged at the injection points in the number required to cover the whole foundation for restoring the object structure (building 1), generally at intervals of about 2 m (the intervals are not limited to this but may be wider or narrower, taking the rigidity of the foundation into account). To each of chemical liquid injection rods 5 at these injection points, the liquid A and the liquid B are supplied from the chemical liquid supply unit 10 installed at a separate place by the high-pressure pump thereof at a required ratio by changing over the selector valve 11 at required intervals by a remote control unit which is not illustrated.

[0025]

With respect to the supply sequence of the chemical liquid injection rods 5 to each of the chemical liquid injection points, the chemical liquid is supplied by changing over the selector valve 11 at predetermined intervals, for example, from the end-most injection point successively to the adjacent position, the second end-most, third end-most, then, fourth end-most, ...and then to the nth injection point. The chemical liquid is supplied, in the case of the above-mentioned chemical liquid, at a supply rate of 10 to 20 L/min and injection change-over intervals of about 10 sec to 2 min (chosen and changed in accordance with the operation progress conditions, taking the soil quality of the ground, estimated structure weight, foundation area, etc. into account).

[0026]

When the chemical liquid is injected in this way, as shown by a in FIG. 3, the flash setting chemical liquid injected for the first time does not receive any big resistance in the ground so that it diffuses in a nearly circular form centered on the injection point within the gelation time and solidifies together with sand and soil. In such an event, the chemical liquid is diffused primarily in the horizontal direction from the discharging end of the chemical liquid injection rod 5. Since its gelation time is about 3 seconds, the solidification begins as soon as it diffuses. Consequently, the initial injection amount is estimated in advance, and then as soon as the scheduled amount is injected, the valve is immediately changed over to the next injection point, and the

injection is carried out at the adjacent position. In this way, the chemical liquid is injected to all the injection points at the required rate. By this kind of operation, in the ground, a nearly circular reinforced ground layer 31 in which the chemical liquid solidified with soil and sand is formed at each injection point. When the chemical liquid is injected in the ground, in the stratum of the sandy layer in which sand particles form the stratum under the non-compressive conditions, the chemical liquid permeates among these sand particles, adheres to the sand particle surfaces and solidifies, and serves as a so-called adhesive and reinforces the permeated area as a group of hardened materials. Thus a stabilized reinforced ground is formed.

[0027]

Then, when the reinforced ground layer 31 at the first injection point comes near to an intermediate point of a process in which certain strength is expressed as a result of chemical liquid reactions, the chemical liquid is injected again from the chemical liquid injection rod 5. Under this condition, the chemical liquid injected previously is homo-gelating as described above (see FIG. 4). Since the strength thereof is still less than 1/2 of the stable range thereof, a part of the reinforced ground layer 31 is split and cracked by pressure exerted to the chemical liquid being injected from the distal end of the chemical injection rod 5, and the chemical liquid is injected inside the reinforced ground layer 31 towards its vicinity.

[0028]

Then, the injected chemical liquid is subject to an obstructing

action to its downward flow caused by the earth pressure force exerted to the ground 30, the load of the building and the reinforced ground layer 31 formed beforehand, unlike the case of the initial injection as described before, so that the chemical liquid flow is limited primarily towards the upper side of the reinforced ground layer 31. Thus, the chemical liquid is injected with the pressure overcoming the earth pressure force and the structure load. As a result, the injected chemical liquid is diffused primarily in the horizontal direction at the reinforced section not hardened yet, and flows in a thin layer generally along the inside of the upper layer of the reinforced ground layer 31, and the chemical liquid injection pressure is accumulated in the liquid state within the range of gelating time (homo-gel). In such an event, since the reinforced ground layer 31 has already been fixed in the ground 30 and the sand layer that forms the ground 30 is non-compressive as described above, a reaction force against the pressure accumulating force of the chemical liquid is exerted to the reinforced ground layer 31, and the stratum above the diffused range of the pressure-accumulated chemical liquid is pushed up. At the same time, the reinforced ground layer 31 is gradually expanded (see FIG. 1 (c)).

[0029]

By the injection (force-injection) of the chemical liquid taken place successively at the above-mentioned intervals at each of the arranged chemical liquid injection points, such an effect is exhibited and the stratum above the reinforced ground layer 31 is gradually lifted

up. Consequently, the chemical liquid injecting operation is repeatedly, successively and continuously carried out at the required intervals at each chemical injection point, and at the same time, the injection (force-injection) point is adjusted in such a manner that the operation is carried out differently between the range with large settlement and the range with smaller settlement of the above structure in accordance with the rising conditions of the stratum, so that the ground will be gradually raised first from the section with greater settlement. Thus, the continuous ground 30 centered on these chemical liquid injection points gradually rises, and the settled foundation of the tilted structure is raised as the ground 30 rises. The rising rate of the structure at the settled section is measured by a measuring instrument in accordance with the progress of the operation, or the level of the floor surface of the building is measured and the chemical liquid injection operation is continued until the structure is restored to the normal condition.

[0030]

By executing the work as described above, as shown in FIGs. 1 (b) through 1(d), the ground 30 that supports the foundation of the structure which is restored from the tilted condition to the normal condition is improved and reinforced as the ground 30 is raised by the chemical liquid injection, and the foundation is stably supported in a wider area. Even when it is hit by an earthquake again, the structure is stably maintained without being subject to the settling phenomenon by fluidizing of soil and sand by the liquefaction phenomenon of the ground 30. By the way, in the restoration operation by the chemical

liquid injection, change-over operation of injection points, control of injection time, adjustment of injection rate, adjustment of injection pressure, etc. can be automated by combining an operator and an automated operation by running an operation program previously set in a control means attached to the chemical liquid supply unit 10. By doing so, it is possible to shorten the construction period and improve economy by automating the restoration operation even if a large number of labor forces are required for its preparation.

[0031]

In the above-mentioned discussion, the restoring method for the unevenly settled building by use of the chemical liquid injection in a building with "raft foundation" was described. In the case of the structure of a construction with the foundation arranged below the body supporting column of the structure (generally called the "strip footing"), chemical injection rods 5 are installed at plural points for the ground 30 of the foundation from the outside of the structure in the same manner as in the above-mentioned case, and by repeating injection (force-injection) of the chemical liquid successively through the chemical injection rods 5 in the procedure same as in the above-mentioned case, a tilted structure can be restored.

[0032]

Next, the second restoring method for the unevenly settled building according to the present invention is a method that can effectively restore and maintain the structure such as a tilted building 1, etc. constructed on the ground 30 primarily comprising a stratum 30a

of a viscous soil such as a silt layer. In this restoring method, pressure is applied to the compressive stratum 30a of the ground 30 that supports the structure foundation and operations for promoting compaction and reinforcement can be used in combination.

[0033]

In this restoring method, first of all, the ground is excavated from the lower foundation (in this example, so-called "raft foundation") of the building 1 to deep inside the ground (if possible, to a rock bed, gravel bed 35, etc.), a plurality of anchors 20 formed of metal bars are suitably driven at the required intervals and in the proportion according to the foundation area, and the head end sections 21 of these anchors 20 are fixed into the ground with a flash setting chemical liquid 5. These anchors 20 may be connected to one piece at halfway by known means as required.

[0034]

A top end section 22 of this anchor 20 is protruded above the foundation and a reaction force is applied to a strong block 25 laid on a foundation 4, and a proper tensile force is applied by a jack 26 (for example, hydraulic jack) by a known means. Thereafter, from the foundation 4 to the bottom thereof, a plurality of double pipe type chemical injection rods 5 are inserted and installed at the required intervals (about 2 m) as described above (in accordance with the first invention), and these chemical liquid injection rods 5 are piped from a separately installed chemical liquid supply unit (not illustrated) via selector valves which are not illustrated, respectively, and the same

chemical liquid as described above is injected at the required intervals as in the above-mentioned procedure.

[0035]

By the chemical liquid injection operation, a reinforced ground layer 31 with the chemical liquid repeatedly injected as described above is formed in the ground 30 below the foundation 4, and by the pressure accumulation action by the injected (force-injected) chemical liquid, the reinforced ground layer 31, the foundation 4 and the building 1 are successively lifted up and the tilted structure is gradually restored to the normal condition. In such event, when the structure (building 1) connected to the deep soil layer section with the anchor 20 is restored upwards by the push-up action by the above-mentioned chemical liquid force-injection, further stronger tensile force is exerted to the anchor 20. As a result, the hardened layer of the ground 30 that supports the structure foundation section pressurizes the compressive stratum 30a like silt layer in the ground 30, and at the pressurized section, the stratum compression action occurs, and quick compaction of the compressive stratum 30a is promoted.

[0036]

If the second restoring method for the unevenly settled building is carried out by these means, the compressive ground 30a is simultaneously improved when the tilted structure is restored. Thus settlement of the ground 30 assumed to occur over a long period of time can be prevented, and the ground is stabilized, as well as effects of preventing influence of uneven settlement on the structure body can be

exhibited. Needless to say, the operation for improving the ground 30 and pressing up the settled foundation section by raising the stratum is the same as that of the first method, and does not cause any interference to its operability.

[0037]

In place of the system to use the anchors 20 in the restoring method for unevenly settled building accompanied by compaction and reinforcement of the compressive stratum 30a, it is able to use a water tank filled with water for the load applied to the structure. For the water tank, a known tank is filled with water and is arranged above the structure foundation so that the required weight is achieved. In the rising process in which the building is lifted up together with the foundation by the chemical liquid injecting operation, by gradually discharging water in the water tank, it is able to easily control the load to the foundation. Consequently, by this system, though a space for installing a water tank is required, the operation for excavation and anchor drilling as in the case of the anchor system is not required, and thus the operation becomes easier.

[0038]

In addition, when the restoring method for the unevenly settled building according to the present invention is executed, permeation of the chemical liquid occurs in the vicinity of the injection point due to the chemical liquid diffused in the ground as it is injected, depending on the environment of the working site. The ground may possibly be raised at a section with a smaller load. Consequently, it is desirable to

take a measure to prevent the chemical liquid from flowing out from the injection point to the area other than the ground below the structure foundation by driving sheet piles in advance to the required depth in the vicinity of the object structure before undertaking the restoration operation. By doing this, the restoration action by the chemical injection can be effectively executed.

[0039]

As described above, according to the present invention, the flash setting chemical liquid is repeatedly injected into the stratum at suitable time intervals and allowed to solidify in an extremely short time to form a compacted reinforced ground layer in a wide area in the ground. Then, making the best of the properties of the formed reinforced ground layer that it is strong against compression and weak against tension, the reinforced ground layer is gradually formed in a large area by the operation for changing over the injection points successively by the required rotation at short intervals to solidify and raise the ground. Then the reaction force is exerted successively to the strongly reinforced ground layer, and the injection liquid pressure is distributed to a wide range to increase the liquid pressure accumulation force to obtain still bigger rising force, and thus the structure can be raised rationally and smoothly. Consequently, no forcible push-up force is exerted to the structure and the intended object can be achieved in a comparatively short time.

[0040]

[Effect of the Invention]

According to the restoring method for the unevenly settled building according to the present invention, since it is a restoring method for gradually lifting up the structure construction ground from the inside of the stratum, the structure can be safely restored without exerting unreasonable push-up force. Further, since no operation to directly exert a large external force to the structure is required and operation is safe, the work can be completed in a short period of time, the construction cost is reduced and remarkable economical effects can be achieved. Because the process can be applied to any structure irrespective of its size, great effects can be exhibited in the restoration of particularly big structures.

[0041]

In addition, by carrying out the installation of the anchors, the settlement of the compressive ground with time can be simultaneously prevented. Therefore, this method is more effective.

[Brief Description of the Drawings]

[FIG. 1]

FIG. 1 shows schematically a mode for restoring a tilted building by a restoring method for an unevenly settled building according to the present invention, FIG.(a) shows the building in the normal condition, FIG.(b) shows that the ground is unevenly settled and the building is tilted, FIG.(c) shows the mode for starting to execute the method according to the present invention, and FIG.(d) shows the mode in which the building is restored to the normal condition by the chemical liquid injection operation according to the

method of the present invention.

[FIG. 2]

FIG. 2 is a plan view showing a plurality of chemical liquid injection points below the building foundation shown in FIG. 1 and the piping for injecting the liquid.

[FIG. 3]

FIG. 3 is a schematic cross-sectional view of the main part showing the mode in which the chemical liquid is being injected.

[FIG. 4]

FIG. 4 illustrates the time point allowing the chemical liquid injection in the strength-time curve of the injected chemical liquid.

[FIG. 5]

FIG. 5 schematically shows the mode in which the compaction promoting operation for the ground is added in the second restoring method for the unevenly settled building according to the present invention.

[Description of Reference Numerals]

1. Building
2. Foundation
4. Foundation section
5. Chemical liquid injection rod
10. Chemical liquid supply unit
11. Selector valve
- 12, 13 Chemical liquid supply pipes
20. Anchor

- 21. Head end section of the anchor
- 22. Top end section of the anchor
- 26. Jack
- 30. Ground
- 30a Compressive stratum
- 31. Reinforced ground layer

(7)

FIG. 1

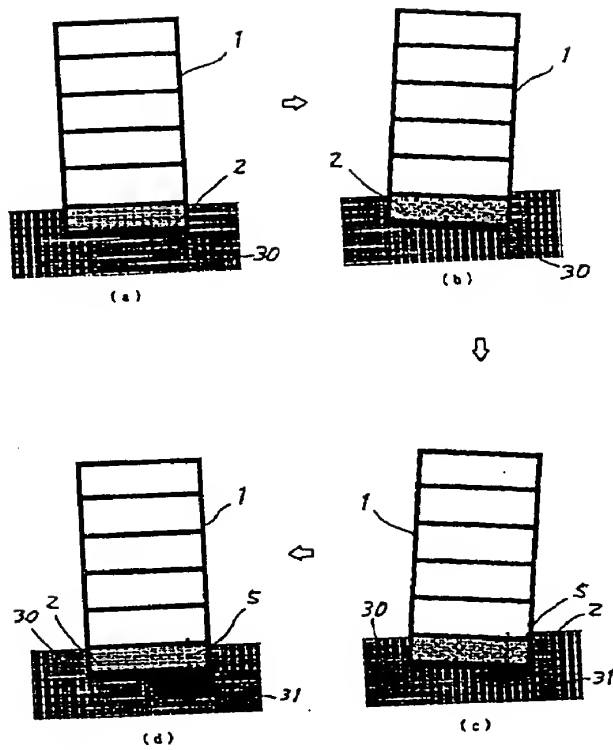


FIG. 2

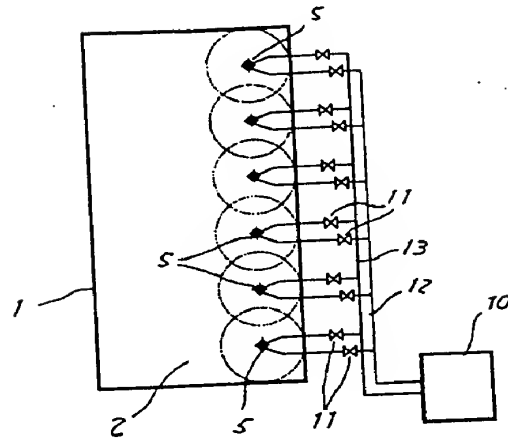


FIG. 3

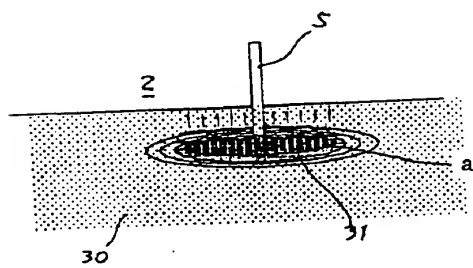


FIG. 4

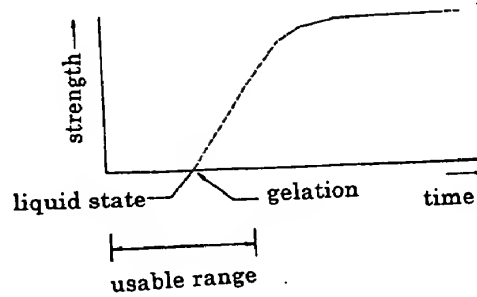


FIG. 5

